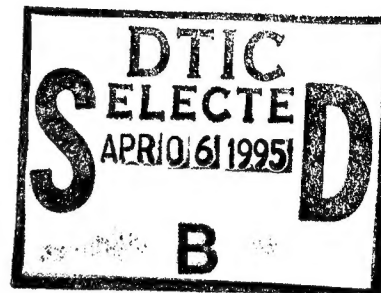


# AOARD REPORT

XV NSO/Sac Peak Solar Workshop held at Sunspot, New Mexico on 19-23 September 1994.

19-23 Sept 1994  
Dr. G. C. Joshi  
U.P State Observatory



With financial support provided under the AFOSR sponsored Window-on-Science program, Dr G. C. Joshi, director of the U.P State Observatory, Manora Peak, Naini Tal, India, presented a paper at XV NSO/Sac Peak Solar Workshop held at Sunspot, New Mexico on 19-23 September 1994. The report includes his technical overview of the workshop. The workshop emphasized the need for new experimental/observational facilities for the theoretical and observational understanding of the corona because there has been no real up-to-date corona spectra measurements done since early 1970. The workshop also discussed how infrared observations can contribute to the understanding of corona, chromosphere, and photosphere as well as night time objects.

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TOKYO, JAPAN  
UNIT 45002  
APO AP 96337-0007  
DSN: (315)229-3212  
Comm: 81-3-5410-4409

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# TRIP REPORT OF Dr. G.C.JOSHI, U.P.STATE OBSERVATORY, MANORA PEAK NAINITAL-263129 (INDIA)

I was invited by the Organising Committee of the XV NSO/Sac Peak Solar Workshop to attend the meeting and that a request was made to AFOSR/AOARD to support the travel expenses. Later on I received a letter from Dr. S. Joe Yakura informing me that AFOSR/AOARD will support my trip.

NSO/Sac Peak being a place of scientific pilgrimage to all the solar scientists, I could not afford to deny the offer and sent my acceptance to attend the workshop. I knew that I will be paid back by AFOSR/AOARD only after submitting the trip report and for that period I had to make arrangements for the money to meet the travel expenses.

Being a Govt. servant, to make the trip possible I had to go to New Delhi which is 400 km away from Nainital to the Ministries of Home, External Affairs and Deptt. of Science and Technology to seek their permission to accept the travel assistance. In the mean time since I did not have the passport, I applied for the same to the regional passport office, which is 200 km away from Nainital. After obtaining the No Objection Certificate from the Home Ministry, External Affairs Ministry and the Ministry of Science and Technology I went to the Nodal Secreary to seek the permission to go abroad to attend the workshop. For visa and ticket I had to go to New Delhi again and finally I started for New Delhi from Nainital to get the flight, two days before, since the entire region to which I belong was and still is under unrest and sometimes it becomes rather impossible to move out of city.

Thus, I reached NSO/Sac Peak on 17th evening via Frankfurt-Dallas-El Paso- Alamogordo. At Alamogordo I was picked up by a car to Sac Peak.

I had not been to Sac Peak before. A solar observer must visit this place, get familiar with various facilities there, meet the eminent scientists and exchange views on the field of research he is working on.

I am grateful to Dr. M.C. Pande and Prof. Raymond N. Smartt for making the trip possible I am also thankful to Drs. S. Keil, Don F. Neidig, Jeff Kuhn, Balasubramaniam, Penn Matt and several others for their help and support. I am also thankful to S. Joe Yakura for the financial support.

I had some useful and vigorous discussions with the scientists at Sac Peak, like William C. Livingston, R.B. Dunn, Lary Wilkins, George Streander, Joe K. Elrod, Guillixson, S. Keil, Keller, Christoph, November Larry, etc. Some of them made me familiar with the various instruments used there, like Vacuum Tower Telescope, Coronagraph, Vector magnetograph, etc. I also exchanged views on our proposed 50 cm Solar Vacuum Tower Telescope about which efforts are going on in Govt. level.

Regarding our procurement of simultaneous filtergrams and magnetograms of solar activity features in six wavelengths namely, H-alpha, H-beta, CaK, HeI (10830), 5324 A and white light through the proposed 50 Cm., f/30 Gregorian type solar vacuum tower telescope, Lary Wilkins was a bit sceptic about the data transfer rate and handling of the enormous data thus available. He said it would really be a challenge to handle such an enormous data. I also exchanged ideas about using a single PC to control more than one CCD. W. Schmidt was of the view that a single PC may not handle more than one CCD particularly if data transfer rate is so high. I had some discussions with Jeff Kuhn regarding procurement of filtergrams in He I 10830 A. He suggested HgCdTe CCD from Rockwell. Prof. Smartt and Dr. Neidig both were very busy and thus could not give much time to the compilation of opinions by various eminent scientists, on our proposed SVT. I could just manage to hand over the reports to Prof. Smartt and Dr. Neidig. S. Balasubramaniam and S. Keil were very appreciative of our work on molecules in IR region. I suggested if NSO people could have some plans to detect the predicted transitions through heterodyne techniques. I was really quite impressed by the adaptive optics techniques that was under progress under the leadership of R.B. Dunn and his team. Tokio Tsubaki and the scientists of NSO were impressed by the sliding roof system of our proposed SVT. Tsubaki suggested that the only alternative could be the type used at Sac Peak. While I was discussing our plans for observing the total solar eclipse (23rd Oct 1995),

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which is passing through India, through a HN 38 polaroid in red (6374 Å) green (5303 Å) and white light in the four different orientations of the polaroid, Y. Suematsu said if sponsored by some agencies, he would like to observe the eclipse. He had no particular plans regarding observing the eclipse of Oct. 1995.

The topic of the 15th NSO/Sac Peak workshop, which was held during Sept. 19-23, 1994 was: Infrared Tools for Solar Astrophysics : What's Next ?

Nearly 65 participants from all over the world were present. Participants were mainly from USA. Nearly 80 papers were presented, out of which 20 were poster papers and 18 were of review nature.

The need for new experimental/observational facilities for the theoretical and observational understanding the corona was emphasised upon in the workshop. There has been no upto date measured coronal spectra since early 1970, they said. There has of course been some efforts recently. The observations that will come out of the new observational facilities will need more accurate atomic models to determine line wavelengths and new ideas about MHD processes in the solar atmosphere. How IR observations can contribute to the understanding of corona, chromosphere, photosphere and also night time objects was also discussed.

The topics that were covered are :

1. What can we expect the from larger reflecting coronagraph telescopes ?
2. In the Far IR what will be the coronal spectrum like ?
3. How accurately we can have measurements of  $T$ ,  $\rho$  and  $\vec{v}$  in the corona ?
4. What information we can get from the He I 10830 Å line ?
5. Use of forbidden lines to measure the magnetic field of the plasma was also discussed.
6. How far the coronal heating models can support observations ?
7. What are the new developments in infrared technology ?
8. What is the use of Large Reflecting Coronagraph in Stellar Physics ?

The workshop started with the introduction by J. Beckers and J. Kuhn followed by Donald F. Neidig who requested the participants to assist in defining, planning and promoting the large reflecting coronagraph by way of submitting one's ideas, however wild they are, about instrument specifications, concept and application.

Sergei Koutchmy then covered a few selected topics to justify the possibilities of having a Large Reflecting Coronagraph. Apart from being the main IR tool for solar astrophysics, it could also be used in fields such as space debris detection etc., he suggested.

Before the start of the paper presentation session, there was a 1h 30m session of self introduction by participants in which every participant was given 2 minutes to tell the audience as to who he is ? Where he is from ? Why he is in the workshop and most importantly about his research interests. This type of practice helps greatly the participants to contact whom, when and where ?

Some important coronal physics questions were touched upon by Zirker, Cargill, Airapetian, November and Altrrock. Zirker and Cargill spoke about coronal heating mechanisms. Zirker proposed three mechanisms of heating of the solar corona and concluded that origin of coronal high temperature remains outstanding question. Valdimir Airapetian and Raymond Smartt used observational parameters of coronal loops interactions of 7 Dec. 1985 to determine values of key plasma quantities.

November and Koutchmy showed that July 11, 1991 white light eclipse corona observations suggest loop cross sections may exhibit a complex structure. Altrrock et al. presented a paper on association of solar temperature and structure from ground based emission line data with Global

Magnetic Field Models and Yohkoh SXT data to investigate large scale structure of the solar corona.

What information can we get from coronal IR spectroscopy was discussed by Chang, Kastner and Penn. Chang and Deming showed that the coronal IR line intensities can be deduced from the abundant UV spectral lines when they share common upper levels and the relevant Einstein A coefficients are known. New ground based coronagraphic observations obtained at NSO/Sac Peak were reported by M. Penn. Penn also reported that the intensity does not appear to vary as  $\text{Ne}^2$  as expected from collisional excitation. It is shown that the line of sight integration in the optically thin corona removes the expected  $\text{Ne}^2$  behaviour while preserving the accuracy of the Ne measurements. Information regarding new IR detectors and IR instrumentation was given by Fowler, Cooper, Hoffman, Rabin, Kuhn, Simons, Jones, Kurtz and Zayer. A.M. Fowler presented his views about low background scientific arrays for the 1-5 micron region while Cooper discussed near infrared HgCdTe 1024 X 1024 FPA for Astronomy. Similarly Douglas Rabin presented the next generation near infrared solar magnetographs suggesting that the next generation magnetographs will also concentrate on near 1.56 micron lines (Fe I,  $g=3$  and  $g_{\text{eff}}=1.53$ , 1.56 micron line). J.R. Kuhn suggested that the IR spectroscopy for measuring the properties of the coronal medium should be explored. He also described recent advances at NSO in IR capabilities. Designs for focal plane array cameras in the band of 0.8 to 28 micron, that have been built by Infrared Laboratories were presented by Robert F. Kurtz.

What information we can have through larger wavelengths was discussed by Bastian, Kaufman and Clark. Bastian discussed radio diagnostics of physical conditions in the solar atmosphere. He showed that continuum radiation on wavelengths longward of 1 mm originates in the Sun's upper atmosphere through a variety of emission mechanisms. As such, it offers a probe of physical conditions in the Sun's outer atmosphere. Kaufmann was of the view that flare emission in sub mm infrared range may contain contributions from thermal and non thermal processes.

New IR coronagraphic telescopes - possible designs were discussed by J. Beckers, Raymond N. Smartt, Bernard Jackson, Christopher Keller, Alexander Epple and J. Kim.

J. Beckers argued that Infrared Solar Astronomy is severely limited by the telescopes and instrumentations it has available and therefore Reflecting Coronagraphs are being developed which would allow both full wavelength coverage, achromatism and hopefully larger apertures to enhance both angular resolution and photon gathering. Prospects of Reflecting Coronagraphs were discussed by Ray N. Smartt. Smartt pointed out that mirror objective coronagraphs offer many advantages compared with the performance limitations of conventional solar coronagraphs. He also briefly described the 5 cm diameter superpolished Si mirror and 15 cm diameter superpolished Zerodur mirror both in a joint program between NSO/SP and IAP. The design of 60 cm aperture coronagraph based on Si-SiC super polished objective mirror was also described with all the capabilities that it will have. Problems of faint source detection and the performance of coronagraphs were discussed and illustrated by C. Ftaclas. Bernard Jackson analysed the possible stray light paths present at the front end of the SOHO C3 coronagraph. T. Roudier narrated about THEMIS, a French-Italian solar facility built jointly by CNRS and CNR. He welcomed the collaboration in the international time facilities, or with French or Italian teams.

THEMIS should be operative in 1996, he hoped. Christoph Keller detailed out the IR capabilities of LEST. He pointed Large Earth Based Solar Telescope will be excellently suited for studies in the near IR up to 2.7 micron. Jean - Claude Vial briefly reviewed the ongoing solar space programs with a special emphasis on SOHO. He also discussed the complimentary nature of infrared observations for specific diagnostics such as temperature etc. with a special attention paid to the He I 1083 nm line. An overview about the installations and first observational results of Pico - a mirror coronagraph of Pic Du Midi was presented by Alexander Epple.

The questions that can be addressed to New Coronagraphic Capabilities was discussed by Don Neidig, S. Koutchmy, David Jewitt, Bernard Fort and Tom Morgan. Neidig's calculations show that for aperture of 2 m, debris of 0.1 cm.diameter in low earth orbit will be detected on short

exposures acquired with IR array detector. This is more than an order magnitude smaller than the limiting debris size that can be detected by conventional telescopes of similar aperture at twilight and yields two orders of magnitude greater detection rate. He also discussed the motivation for acquiring measurements of orbiting debris. David Jewitt gave an overview of the application of coronagraphs to the study of astrophysical problems outside the sun. Observations of the star Beta Pic around which the disk has already been known through stellar coronagraphy were discussed. Results of survey for similar structures around other stars were also discussed. Bernard Fort discussed the basic concept of major lensing applications where the use of a new generation of wide field coronagraphs would be invaluable. Thomas H. Morgan showed how coronagraphic techniques have proven useful for detection and photometric or spectroscopic observation of a faint object in the presence of much brighter body and also of faint extended structures about bright central objects.

Tokio Tsubaki made the audience aware of the fact that the share of coronal studies has continuously increased upto 15%, which is nearly the same as that of the flares.

New results from IR chromospheric and photospheric spectroscopy were discussed by Ayres, Avrett, Lindsey and Stein. Avrett carried out a systematic analysis of the IR CO lines (2.3 to 6.7 micron) observed at the centre of the solar disk by Farmer and Norton (1989) with Spacelab - 3 ATMOS experiment. Lindsey discussed theory of radiative transfer in inhomogenous media while Ayres gave a review on thermal bifurcation. Stein concluded that the Sun may not have a chromosphere in magnetic field free internetwork regions.

IR magnetic diagnostic photometry were discussed by Solanki, Lin, Schmidt, Rimmele, Balasubramaniam, Ruzmaikin, Knoelker, Muglach and Penn. Solanki gave an overview of the current status of observations of solar magnetic features such as sunspots, pores and magnetic elements. Recent observations suggest that large pores have a complex magnetic structure as sunspot penumbrae. Lin presented some new data relating to IR continuum contrast, magnetic field, filling factor and magnetic flux.

Using the observations of Vacuum Tower Telescope on Tenerife, Schmidt determined magnetic fields and velocities in bright umbral structures observed in Fe 1027 nm. Rimmele compared velocities inferred from the IR data to those measured in the Fe I 5576 A line and found several cases wherein the 1.56 micron Stokes - V profiles indicate strong flows in magnetic regions. A paper on magneto - optic effects on Fe I 1.56 micron line was presented by K.S. Balasubramaniam.

Near IR (1083 nm) diagnostics were discussed by Suematsu, Schmidt, Kin, Bocchialini, Ruedi and Fleck. Suematsu presented some results on studies of observations taken in He I 10830 A line since 1989 at Norikura Solar Observatory. Limb observations of the 10830 A line were presented by W. Schmidt. According to him this line is very useful and powerful diagnostics for chromospheric magnetism.

Bocchialini presented a paper on wave properties of the chromosphere in 1083 nm. I.S. Kim showed that the intensity ratio of He (10830)/H-alpha seems to be an index of prominence dynamics and probably stage of evolution. Paper on chromospheric magnetic field measurements in He I 10830 A line was presented by Ruedi. Fleck told the audience what all have we learnt about chromospheric oscillations from He I 10830 A. Fleck showed that the oscillation amplitude observed in the He I 10830 line is only half the velocity amplitude derived from the core displacement of CaK<sub>3</sub>.

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